Space Weather Technical Forecast

Issued on Sunday 12 January 2025 at 01:15 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of isolated M-class flares. Slight chance of G1-G2/Minor-Moderate Geomagnetic Storms Day 1-2 (12-13 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low solar activity with only C-class flares observed. There are now nine sunspot regions on the visible disc, with AR3951 now decayed. AR3947 remains the largest and most magnetically complex group. This region has been responsible for the majority of flare activity over the past few days and maintains a small delta spot in its trailing region, however, many of the intermediate spots have tended to decay in recent hours. AR3953 in the northwest continued to see some slight decay of its constituent spots. AR3956 in the northeast remains a simple, mature region, but has had some development of its intermediate spots in recent hours. The remaining regions on the disc remain small and simple with limited overall change.

A lack of recent SOHO coronagraph imagery, combined with large gaps in STEREO coronagraph imagery has meant that the detection of CMEs has been more challenging than usual. However, SOHO imagery has recently returned and does not indicate any Earth-directed CMEs during the period.

Solar Wind / Geomagnetic Activity: Solar winds observed at L1 by ACE/DSCOVR have been slightly elevated throughout the period, varying between 400-480km/s. The density of the solar wind was below average. The Interplanetary Magnetic Field, Bt, was largely weak, aside from a brief moderate period (peak 9nT) during the afternoon. The north-south component, Bz, was mainly weak and variable, ranging between -5nT and +7nT. The Phi angle was mainly positive (away from the Sun) with brief negative (towards the Sun) intervals. Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES-18 was at background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels. The associated 24 hour fluence remained below the Active threshold on a slight declining trend, reading 2.86e6 integrated pfu at 12/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate, with a chance of further M-class flares and a very slight chance of isolated X-class flares, mainly due to AR3947 in the northwest disc or any spots that rotate over the eastern limb later in the period.

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Solar Wind / Geomagnetic Activity: A lack of SOHO coronagraph imagery and STEREO imagery means that CME analysis has been extremely difficult and comes with significant uncertainty for the forecast period. A possible filament eruption from near AR3947 on 09 Jan may bring some enhanced geomagnetic activity over Day 1 or Day 2 (12-13 Jan), but is very low confidence in terms of a possible arrival and timings. Solar winds are currently slightly elevated due to the ongoing HSS of a coronal hole. This is expected to decline by the end of Day 2 (13 Dec) with speeds returning to normal background levels. Fast winds from another coronal hole is expected to bring some minor enhancement from Day 3 (14 Jan).

Geomagnetic activity is expected to be mainly Quiet to Unsettled between Days 1 and 2 (12-13 Jan), but with a chance of G1 to G2 Minor/Moderate Storms on Days 1 and 2 should any CME influence be forthcoming (very low confidence). On Day 3 (14 Jan) activity is expected to increase to Unsettled to Active levels, following the onset of the HSS from CH08/-, with a chance of peak G1/Minor Storm conditions.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is expected to remain at background levels, with only a slight chance of rising in response to any notable flares. GOES16 high energy electron flux is forecast to continue at normal background to moderate levels at first, perhaps rising to high through the forecast period. Electron fluence is not expected to reach the Active threshold, although a rising trend is likely later in the period. Electron flux and associated fluence forecast carries much lower confidence than usual given the possibility for CME influence over the UTC weekend.

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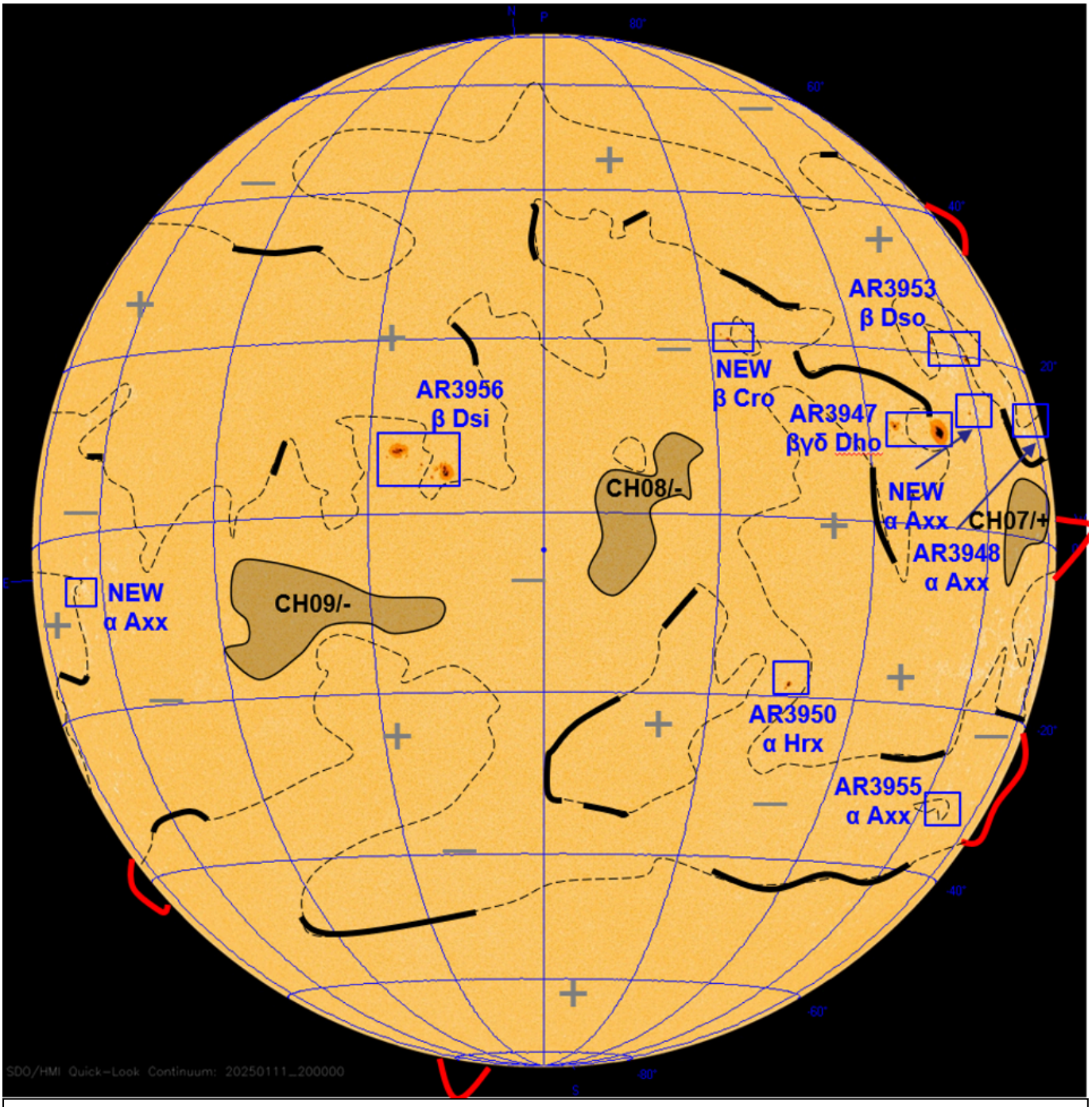
Figure 1: MOSWOC Solar Synoptic Map valid 11/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Solar winds are currently slightly elevated due to the ongoing connection to the HSS of CH07/+, with observed speeds of around 430km/s at the time of issue. Speeds should gradually decline through Days 1 and 2 (12-13 Jan) to normal background levels. The next HSS enhancement is expected to be CH08/-, currently near centre disc in the northern hemisphere. Given its current location it is forecast to become geoeffective on Day 3 (14 Jan) with speeds most likely increasing to slightly elevated to elevated levels. This doesn't appear to be a reoccurring feature, however the MOSWOC Enlil output is giving speed estimates of around 550km/s (elevated) from Day 2 (13 Jan). That being said, it is thought that Enlil's onset of the fast winds from CH08/- is too early and potentially also affected by a CME arrival at a corresponding time in the rotation in December, so its output is viewed with caution with respect to this.

A filament eruption to the northeast of AR3947 appears on SDO/AIA 304 imagery and GONG H-alpha around 09/1030 UTC with an associated long duration C-class flare. Given the recent lack of SOHO coronagraph imagery, combined with large data gaps in STEREO imagery its difficult to ascertain if any material was directed towards Earth as a result of this event. Given its location near centre disc, it is possible that we could see an Earth-directed component, but this is treated with significant uncertainty. Estimating a CME speed of between 500-1000km/s would bring impacts at Earth somewhere between early (UTC) on Day 1 (12 Jan) to the early hours Day2 (13 Jan), but carries very low confidence. This potential CME does not feature in the 'Earthbound Coronal Mass Ejections' table given the high levels of uncertainty with this event.

Geomagnetic activity is expected to be mainly Quiet to Unsettled between Days 1 and 2 (12-13 Jan), but with a chance of G1 to G2 Minor/Moderate Storms on Days 1 and 2 should any CME influence be forthcoming (very low confidence). On Day 3 (14 Jan) activity is expected to increase to Unsettled to Active levels, following the onset of the HSS from CH08/-, with a chance of peak G1/Minor Storm conditions.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	20	15
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Radio Blackouts - X-Ray Flares

Low solar activity during the last 24 hours with only C-class flares.

There are now nine sunspot regions on the visible disc, with AR3951 now decayed. AR3947 remains the largest and most magnetically complex group. This region has been responsible for the majority of flare activity over the past few days and maintains a small delta spot in its trailing region, however, many of the intermediate spots have tended to decay. AR3953 in the northwest continued to see some slight decay of its constituent spots. AR3956 in the northeast remains a simple, mature region, but has had some development of its intermediate spots in recent hours. The remaining regions on the disc remain small and simple with limited overall change.

Evidence of magnetic looping in SDO 171 imagery near the eastern limb suggests the potential for new regions to rotate onto the facing-disc in the coming days. Helio-seismic data is supportive of this and corresponds to expected locations for Ex-AR3927, Ex-AR3929 and Ex-AR3933. The latter two regions were responsible for M-class flares when last on the disc in late December. AR3947, which currently dominates flare probability contributions, will rotate over the western limb on Day 3 (14 Jan).

Overall, there is a chance of M-class flares, with a very slight chance of isolated X-class flares, mainly due to AR3947 or any spots that rotate over the eastern limb later in the period.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	30	30	40	40
Very Active	R3-R5 (X Class)	No	5	5	5	5

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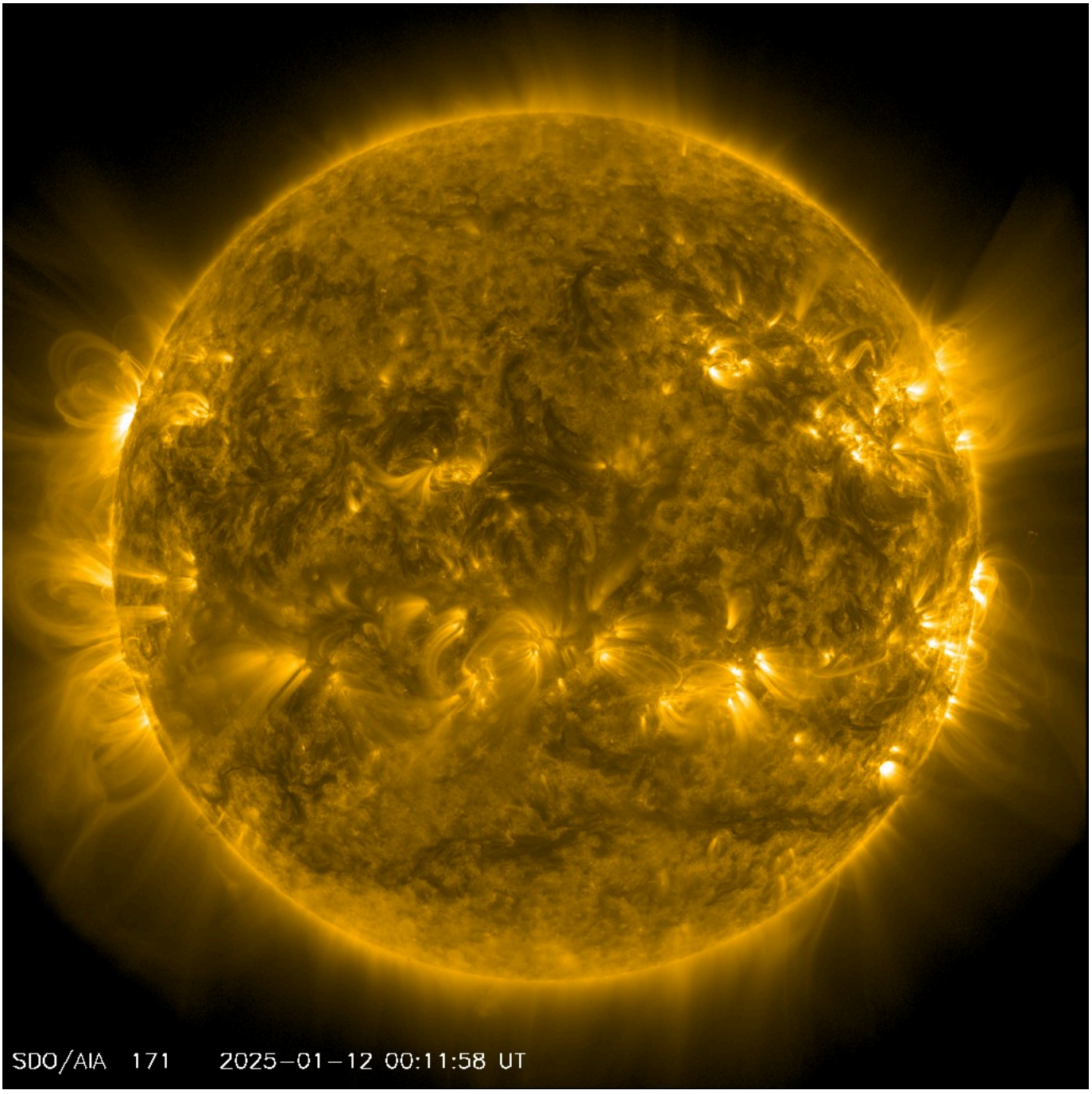
Figure 2: GOES-16 SUVI 171 Angstroms image at 11/1304 UTC. Note the magnetic looping near the eastern limb, likely associated with returning sunspot regions in the coming days.



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Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has remained at background over the last 24 hours. There is a slight chance of an enhancement as AR3947, the most complex spot, continues to transit the western hemisphere during the forecast period, rotating off of the visible disc on Day 3 (14 Jan). This region has been the source of many M-class flares and isolated X-class flares, albeit with less in the way of significant flares recently. Furthermore, there are a number of filaments currently on the disc, and it is not impossible that a large eruption from any of these could result in Earth-directed high energy protons.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 has been at normal to moderate levels during the past 24 hours. The ongoing connection to the fast winds from CH07/+ appears to have suppressed the electron belts away from the location of GEO. As the solar wind speeds begin to ease in the coming days, we would expect the Van Allen belt to expand back to incorporate GEO and given the two recent fast wind events from an earlier connection to CH05/+ and now CH07/+ the electron belts are likely to have been charged up. As a result we may see electron flux rise day-on-day, increasing to moderate, perhaps diurnally high levels. Complicating matters, however, is the possibility of a CME from the 09 Jan filament eruption arriving Day 1-2 (12-13 Jan), which could see the electron belts becoming suppressed again. Overall, it is probable that electron flux values will be at background to moderate levels at first. Without any CME influence the electron flux is likely to increase later in the period, with diurnal high peaks becoming increasingly likely with time, ahead of any onset from the HSS from CH08/- on Day 3 (14 Jan), after which electron counts are expected to fall again.

Electron fluence will remain below the Active threshold at first, but a rising trend is possible later in the period if the electron belts expand out once more and especially if there is no CME observed. REFM seems a reasonable guide currently, perhaps not expressing enough of a rising trend later in the period as currently indicated. Overall, this forecast is lower confidence than usual with the ongoing uncertainties in the Geomagnetic forecast.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	10	10
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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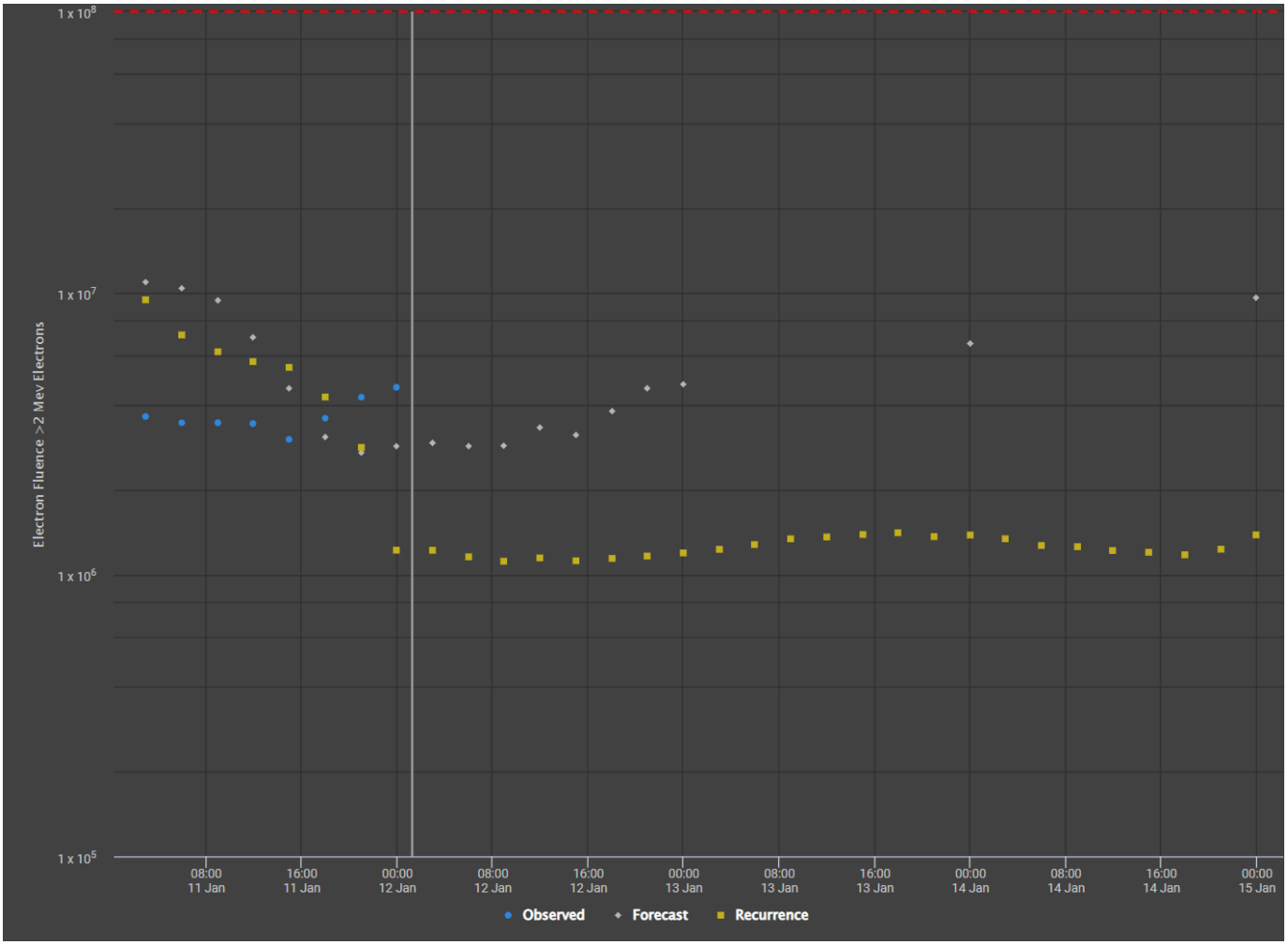
Figure 3: MOSWOC REFM forecast and Recurrence



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